Melbourne Water Corporation

Report for Sugarloaf Pipeline Project

Habitat Slab Experiment

September 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Abbreviations

Alliance	Sugarloaf Pipeline Alliance
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (now DSEWPaC)
DNRE	Victorian Department of Natural Resources and Environment (now DSE)
DSE	Victorian Department of Sustainability and Environment
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EMP	Environmental Management Plan
EMS	Environmental Management Strategy
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
EVC	Ecological Vegetation Class
Experiment	Habitat Slab Replacement Experiment (HSR)
FFG	*Flora and Fauna Guarantee Act 1988*
FIS	Flora Information System
GBCMA	Goulburn Broken Catchment Management Authority
GHD	GHD Pty Ltd.
GSM	Golden Sun Moth
HLPS	High-lift Pump Station
HSR	Habitat Slab Replacement
MWC	Melbourne Water Corporation
ROW	Construction Right of Way
SLL	Striped Legless Lizard
sp.	Species (one species)
spp.	Species (more than one species)
subsp.	Subspecies
var.	Variety
VROT	Victorian rare and / or threatened species

1. Introduction

1.1 Project Background

The purpose of the Sugarloaf Pipeline Project was to construct a 70 km pipeline and associated facilities to transfer water from the Goulburn River near Yea to Melbourne's water distribution network via the Sugarloaf Reservoir (SLPA 2009a).

The Project was delivered by the Sugarloaf Pipeline Alliance (the Alliance), which comprised Melbourne Water Corporation, GHD Pty Ltd, Sinclair Knight Merz Pty Ltd, and John Holland Group. The Alliance was responsible for planning and environmental assessments, engineering design, community and landowner consultation, project management and construction associated with the Project (SLPA 2009a).

The Alliance recognised that some environmental impacts were likely to occur as a result of the Project. Thus the Alliance adopted the principles of the 3-step "Avoid-Minimise-Offset" hierarchy in order to manage potential environmental impacts. Through the planning and design process for the project as a whole, ecological values and risks that could potentially occur along or near the preferred alignment options were identified. Wherever possible, measures to avoid these impacts have been undertaken. However, it was not always possible to avoid all ecological impacts, due to a lack of alternative impact-free options or due to other environmental, social or economic constraints. In these instances, many possible management responses were identified for the purpose of minimising unavoidable impacts upon ecological values. Through a risk assessment process, and in consultation with the Victorian Department of Sustainability and Environment (DSE) and the federal Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), some specific measures (from the range of possible management responses) were then adopted by the Alliance to minimise impacts that were unavoidable. Offset actions for unavoidable impacts to native vegetation are addressed primarily through the Offset Management Plan, although some compensatory actions were also implemented specifically for fauna, including specific compensatory actions for the Golden Sun Moth (SLPA 2009a).

1.2 GSM and Environmental Approvals Requirements for the Project

1.2.1 The Golden Sun Moth

The Golden Sun Moth, *Synemon plana* (GSM), is listed as 'critically endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The GSM has also been listed as a threatened species in accordance with Section 10 of the Victorian *Flora and Fauna Guarantee (FFG) Act 1988*. Most invertebrates are not listed under the *Wildlife Act 1975*. However, as the GSM is listed as a threatened species on the FFG Act, it is also listed as 'protected' under the *Wildlife Act 1975* (SLPA 2009a).

For most of the GSM's life-cycle, the species is present only as larvae, which remain in the soil below the ground surface (DEWHA 2009). They are thought to feed on the roots of grasses. It is not known how long individual GSM remain as larvae, but it is suspected to be greater than one year and possibly up to three years or more. Larvae eventually pupate into non-feeding adults, which emerge for reproductive activities. On an annual basis, adult GSM typically emerge from late October through to early January, although each individual adult moth is thought to typically live for only five days or less after emerging.

1.2.2 GSM Approval Requirements

Some environmental impacts identified as likely to occur as a result of the Project included impacts on threatened flora and fauna species. During 2007 and the first half of 2008, various information sources were used to obtain a better understanding of the potential occurrence of threatened species in the vicinity of the Project area and surrounds. As a result of this process, ecologists from the Alliance concluded that a number of threatened fauna species could use habitats within the project area to some extent. This included the possibility that one or more populations of the Golden Sun Moth persisted within grasslands and open grassy woodlands within the Construction Area and immediate surrounds. The potential areas for the GSM occurred along the pipeline alignment and associated infrastructure from Devlin Bridge (along the Melba Highway) northwards to the Goulburn River (a distance of *c.* 25 km). The likelihood of GSM populations actually occurring in the area ranged from highly unlikely to possible (SLPA 2009a).

Due to constraints such as timing restrictions and limited access to private land, no surveys for the GSM were conducted prior to the project approvals process (i.e., no surveys were conducted for the GSM during the flight season in late 2007-early 2008). In the absence of targeted GSM surveys, areas of potentially suitable habitat for the GSM within the Construction Area were identified and mapped as "possible Golden Sun Moth grassland habitat" as a precautionary measure. The EMS Mitigation Plan stated that targeted surveys would be undertaken for the species prior to the commencement of construction in areas that were identified as possible GSM grassland habitat (SLPA 2009a).

Project approval was granted in mid-2008 with a number of conditions. The key condition was that the EMS Mitigation Plan must be implemented in its entirety. Another condition re-iterated that the Alliance could not commence construction activities within any areas mapped as possible GSM habitat until a defined minimum level of targeted GSM survey was conducted during the 2008-09 flight season (late October 2008 to early January 2009). The project conditions also stated that if any GSM populations were found, then the Alliance would trial Habitat Slab Replacement (HSR) as a measure to investigate ways to reduce impacts upon the species during the construction phase of the Project. A suitable compensation/offset package would then be provided if a decline in a GSM population was detected. Any decline would need to be detected during two years of monitoring following the completion of construction activities (SLPA 2009a).

1.3 History of the Habitat Slab Replacement Experiment

The Golden Sun Moth (*Synemon plana*) (GSM) occurs in grasslands and open grassy woodlands in south-eastern mainland Australia. The native grassland and grassy woodland habitats used by the GSM are amongst the most threatened of all vegetation types in Australia, with more than 99.5% estimated to have been grossly altered or destroyed (DEWHA 2009, Kirkpatrick et al. 1995, Lunt 1991). The GSM is generally found in grassy habitats that are dominated by native grass species, but they have also been occasionally found within areas dominated by non-native grasses. The species is listed as 'critically endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999,* 'threatened' under the Victorian *Flora and Fauna Guarantee* (FFG) *Act 1988* and 'critically endangered' on the Department of Sustainability and Environment (DSE) *Advisory List of Threatened Invertebrate Fauna in Victoria 2009* (DSE 2009).

In late 2008, targeted surveys undertaken by the Alliance identified the presence of flying adult GSM at a number of locations along the proposed Construction Area Right of Way (ROW) for the Sugarloaf Pipeline Project ('the Project'). Most observations were within the 3-5 km section of the alignment south of Yea, including the property proposed to contain the Sheoak High Lift Pump Station (HLPS)[1] (SLPA 2011).

One of the post construction monitoring experiments designed to both help mitigate the impacts of the project on GSM, and to further develop scientific understanding of the species was the Habitat Slab Replacement Experiment which is described in section 7.1.3 of the Fauna Management Program – Sheoak High Lift Pump Station (SLPA 2009b).

1.4 Objectives of this Report

The objectives of this report are as follows:

- Provide an overview of the history of the project;
- Provide an overview of the history of the Habitat Slab Replacement experiment;
- Outline the methods of the flora monitoring undertaken as a part of the experiment;
- Describe the results of the flora monitoring undertaken as a part of the experiment;
- Briefly summarise the results of the fauna monitoring undertaken as a part of the experiment;
- Discuss the implications of these results; and
- Provide recommendations for future management / monitoring.

[1] The Sheoak property is owned by Melbourne Water; a member of the Sugarloaf Pipeline Alliance.

1.5 Study Area

The research was confined to grazing land to the south of Yea, in the Central Highlands Bioregion, Victoria. The Habitat Slab Replacement experiment was undertaken at six locations along the Sugarloaf Pipeline ROW, all of which contain **known** GSM grassland habitat (i.e. GSM was located at these locations before construction of the pipeline commenced). Two locations occur on the Sheoak property (#326), two occur on property #335, and one occurs on each of properties #327 and #328. Given the geographical spread of the six experimental sites (See Figure 1), each experimental site required its own control plots (SLPA 2011).

LEGEND

- Habitat Slab Replacement areas
- Property
- Construction ROW

Paper Size A3

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Sugarloaf Flora Monitoring

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Revision	A
Date	17 Aug 2012

Figure 1

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Hazelwood Drive (cnr Lignite Court) Morwell VIC 3840 Australia **T** 61 3 5136 5800 **F** 61 3 5136 5888 **E** mwlmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro (saved 17/8/2012), Created by:cillingworth

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1.6 Limitations

Some issues arose throughout the course of the experiment that may have had some issues on the results of the experiment.

1.6.1 Experimental Design

As this was the first time this kind of experiment had been undertaken, there was no guide to follow on how exactly to undertake the flora monitoring, and what parameters to look at and how to measure them. Methods needed to be devised in order to enable all field staff to measure vegetative factors in the same way. Determining the 'Inter-tussock distance' was initially problematic, until specific guidelines were devised on the diameter a tussock needed to reach to be considered classified as a tussock (3 cm), and which species would be considered a tussock, and how to assess rhizomatous species (i.e. *Cynodon dactylon* var. *dactylon*, Couch). The method was adapted to account for these factors taking into account the habitat requirements of the GSM and what parameters would be the most useful to determine habitat value across the sites.

1.6.2 Land Access

Some monitoring rounds were slightly delayed due to issues with land access for private properties. Where relevant these issues have been described below within this report.

It should be noted that the hand-held GPS units used to record site information are accurate to within 10 m only. Therefore, the maps presented in this report displaying site information and species records should not be relied on for the detailed design during the construction process.

1.7 Compliance with Management Plans

This report outlines the vegetation monitoring undertaken in accordance with the measures outlined in Section 7.1.3.4 Section F of the Fauna Management Program - Sheoak High Lift Pump Station (SPLA 2009b). Some changes to the monitoring became necessary when considering the practicalities of collecting the data in the field, with the changes being:

- No recording of tussock density or tussock condition and survivorship. These measures proved impractical to measure reliably in the field due to difficulty in identifying individual tussocks in the majority of instances. This also proved difficult at some of the experimental sites before the experiment began and it was concluded that these measures would not provide useful or comparable data; and
- Structure was measured in four classes, which are indicative of plant form and maturity rather than 10 cm intervals which proved impractical to measure in the field. The height intervals were 0–10 cm, 10-30 cm, 30-100 cm and over 100 cm.

These changes to the methods were revised within the GSM overarching document (SLPA 2009a). The updated overarching GSM document was submitted to DSE in August 2009.

The required photographs and monitoring data have been collected at three monthly intervals with this report describing changes noted in the latest round of monitoring (August 2011).

2. Methods

2.1 Field Survey

The Habitat Slab Replacement experiment was undertaken at six locations along the ROW, all of which contain **known** GSM grassland habitat (i.e. GSM was recorded at these locations before construction of the pipeline commenced). Two locations occur on the Sheoak property (#326), two occur on property #335, and one occurs on each of properties #327 and #328. Given the geographical spread of the six experimental sites, each experimental site required its own control plots. An example of the changes in the vegetation and general condition of the sites for the experiment is displayed in Table 1.

Table 1 Example in the changes in vegetation condition with the Habitat Slab Experimental Area on property 335

<table>
<tr><td>Habitat Slab experimental plots at property 335, immediately after slabbing, May 2009</td><td>Habitat Slab experimental plots at property 335, 23 months after slabbing, April 2011</td></tr>
<tr><td></td><td></td></tr>
</table>

At each location, there were ten delineated rectangular plots (each with an area of 8-9 m x 10 m; 80-90 m^2), which comprise:

- One 'undisturbed' control plot outside but adjacent to the ROW;
- One 'disturbed' control plot within the 'non-slabbed' area of the ROW;
- Four plots of replaced slabs ('set down areas') within the ROW (one of each of four experimental treatments); and
- Four laydown plots outside but adjacent to the ROW (one for each of the four treatments).

2.1.1 Treatment Definitions

Undisturbed Control

Undisturbed ground *outside* ROW, but adjacent to (i.e. within 30 m of) the section of ROW that is slabbed.

This control is required to provide information on GSM habitat similar to that in the slabbed areas, but which remains undisturbed for the course of the experiment and monitoring period (i.e. to determine what happens to the GSM population in the absence of disturbance). The assumption is that the habitat immediately adjacent to, but outside the ROW, is equivalent to the slabbed area within the ROW with respect to the local GSM population. Areas chosen for the experiment were selected in part on the basis of meeting this assumption (based on observed superficial habitat characteristics rather than GSM pupal case surveys).

Disturbed Control

Disturbed ground within ROW that is not slabbed. That is, for this 'maximum disturbance' control, the standard construction and reinstatement process for grassy agricultural paddocks that are intercepted by the project was implemented.

In most situations where the project intercepts grassy vegetation, the topsoil was stripped from the ROW initially, stockpiled for the duration of construction, and then returned to the ROW at the completion of construction. Standard reinstatement then proceeded, with grasses from the topsoil seedbank encouraged to regenerate across the ROW - without any direct plantings of seeds or tubestock, and without any addition of fertilisers, herbicides and pesticides (at least not without the permission of DSE and/or the GSM Technical Advisory Group).

This control provides information on GSM and vegetation survival and/or recolonisation in the absence of the Habitat Slab Replacement (i.e. if nothing is done to mitigate against impacts to GSM).

Set Down Areas

Set down areas consist of the experimental slabs themselves. Four different treatments were utilised:

a) Slabs 20 cm deep, stored during construction on geotextile fabric directly on ground;

b) Slabs 20 cm deep, stored during construction on solid boards raised off the ground (without fabric or matting);

c) Slabs 45 cm deep, stored during construction on geotextile fabric directly on ground; and

d) Slabs 45 cm deep, stored during construction on solid boards raised off the ground (without fabric or matting).

Laydown Areas

Laydown areas were located adjacent to but outside the ROW, but still within the approved development corridor.

The temporary storage of habitat slabs outside the ROW is likely to impact the ground and vegetation within the storage area. If that storage area also contains suitable GSM habitat, then the additional potential impact needs to be factored in to the overall benefits or impacts of the slab replacement procedure.

Flora monitoring has now been undertaken on eleven occasions within each of the 60 plots (6 locations x 10 plots). This monitoring is described in more detail below.

Table 2 Example of some of the methods employed to set up the experiment

Monitoring Round 0 – conducting floristic surveys of site being prepared to become a 'Laydown Area' using Geotextile Fabric	Placing Geotextile Fabric on the ground to create a temporary 'Laydown Area'
	
Placing solid boards across the ground to create a raised temporary 'Laydown Area'	
	

‘Cutting’ up the ‘slab’, piece by piece, using the excavator, so it can be moved to a temporary laydown area during construction	An area fenced off as a control area in May 2009
	

2.1.2 Timing of Monitoring

Monitoring was undertaken in accordance with the method outlined in the Golden Sun Moth Overarching Document (SLPA 2009a) and the Fauna Management Program – Sheoak High Lift Pump Station (SLPA 2009b).

Monitoring included an assessment of the following factors:

- Full species list including native and introduced flora species;
- Braun – Blanquet cover abundance of each species within each plot;
- Braun – Blanquet cover abundance of each life form within each plot (e.g. graminoids, forbs);
- Braun – Blanquet cover abundance of bare ground within each plot;
- Vertical structure of each life form within each plot; and
- Inter-tussock distance in four quadrants as measured at ten random points within each habitat slab (i.e. total of 40 measured distances per location).

The dates of each round of flora monitoring for the habitat slab experiment are documented in Table 3 below.

Table 3 Flora monitoring undertaken to date for the Habitat Slab Restoration experiment

Assessment type	Date
Pre-slabbing assessment	May 2009 (Slabs removed)
Post-slabbing assessment round 1	June 2009 (1 month after slab removal, slabs were being stored adjacent to the ROW)
Post slabbing assessment round 2	July 2009 (2 months after slab removal, slabs were reinstated for this assessment)

Assessment type	Date
Post slabbing assessment round 3	October 2009 (5 months after slab removal)
Post slabbing assessment round 4	February 2010 (8 months after slab removal)
Post slabbing assessment round 5	April 2010 (11 months after slab removal)
Post slabbing assessment round 6	July 2010 (14 months after slab removal)
Post slabbing assessment round 7	October 2010 (17 months after slab removal)
Post slabbing assessment round 8	January 2011 (20 months after slab removal)
Post slabbing assessment round 9*	April 2011 (23 months after slab removal)
Post slabbing assessment round 10**	August 2011 (27 months after slab removal, 25 months after slab reinstatement)

* Access was not able to be gained to properties 327 and 328 during the April 2011 survey period due to landholder issues. Therefore, no data were collected for the two locations on these properties for this round of monitoring, which means that only four of the six experimental locations (i.e. 40 of the 60 plots) were assessed. Landowner issues were resolved for the most recent survey period- August 2011- and all sites were assessed.

** Access was not able to be gained to properties 327 and 328 until August 2011. To keep the final monitoring round consistent all of the slabs (across all of the properties) were assessed over consecutive days in August 2011.

2.2 Statistical Analysis

For the statistical analyses, the <0.1 m and 0.1<0.3 m categories were merged, and the 0.3-1.0 m and >1.0 m categories were merged, to enable data to be analysed and interpreted in a more manageable and meaningful way. There were also very few data points in the <0.1, and >1.0 m categories over the course of the sampling. This summation means that some of the data for cover in the latter stages of the sampling (i.e., 2011) resulted in figures > 100% cover. In addition, the four set down treatments were merged as exploratory data analysis indicated there was little or no variation in the data over time for the different types of treatments. This also assists the discussion and interpretation of the differences between the broad treatment types (i.e., control, slab, laydown).

The variation in the composition of the “environment” (that is, how did the combination of all the key vegetation and structural measures change over time) across the treatment sites was examined with ordination via multi-dimensional scaling. For each treatment the vegetation and structural data were averaged for each of the six survey locations, and then normalised and transformed into similarity matrices using Euclidian distance (Clarke and Gorley 2006). A trajectory line was then added to the increasing time periods since initial slabbing. This provides a universal measure of relative change from each sampling period, i.e. the greater the distance between two time point, the greater the extent of change in the combined the environmental variables. The vegetation and structural measures used in this analysis were; Native tussock (%), Native forbs (%), Bryophytes / lichen (%), Litter (%), Introduced tussocks (%), Introduced forbs (%), Bare ground (%), Introduced species cover (%), Total species richness, Native species richness, Introduced species richness, *Austrodanthonia* spp (%), *Austrostipa* spp (%), Inter-tussock distance (cm), Native grass cover <0.3 m, Native grass cover >0.3 m, Introduced grass cover <0.3 m, Introduced grass cover >0.3 m.

We then examined the variation in vegetation and structural factors (as above) over time by testing for the relationship with treatment, months since initial slabbing and interaction. We used the general mixed linear models in Genstat 8 (Payne et al. 2010), with the six discrete slab sites as the random effect. Mixed models combine both fixed and random terms and estimate the variance within a group against the variance between groups for the random term. Using site as a random terms controls for site variation that might have been anomalous and biased any treatment or time effect. Variance components were estimated using the residual maximum likelihood and fixed effects using weighted least squares. The significance of the fixed effect is assessed via the Wald statistic (Payne et al. 2010) (see Table 4).

To illustrate any significant effects we calculated the mean and standard error for each vegetation and structural factors over increasing time (months) since slabbing (Table 5), and graphically illustrated the mean and standard error for key environmental factors over increasing time (months) since slabbing, but categorised by treatment (See Figure 3 - Figure 12).

3. Flora Results

Data analysis has been undertaken to determine the trends observed across the six slab sites for the 27 month monitoring period (May 2009 – August 2011).

3.1 Rainfall over the 27 Month Monitoring Period

In May 2009 the habitat slabs were extracted, relocated and replaced within the ROW. Each treatment at each property was assessed floristically prior to the extraction of the slabs (May 2009, Round 0). Subsequent to this, GHD undertook floristic assessments an additional nine times between the period May 2009 to August 2011. Figure 2 displays the total rainfall per month (Seymour weather station, BOM 2012) during the course of these assessments (rounds). The peak rainfall over the assessment period occurred in January 2011 (Round 8 of monitoring) with a total rainfall of 137.8 mm falling. The range of rainfall over the assessment period was 10.6 mm to 137.8 mm with an average of the period of 72.6 mm.

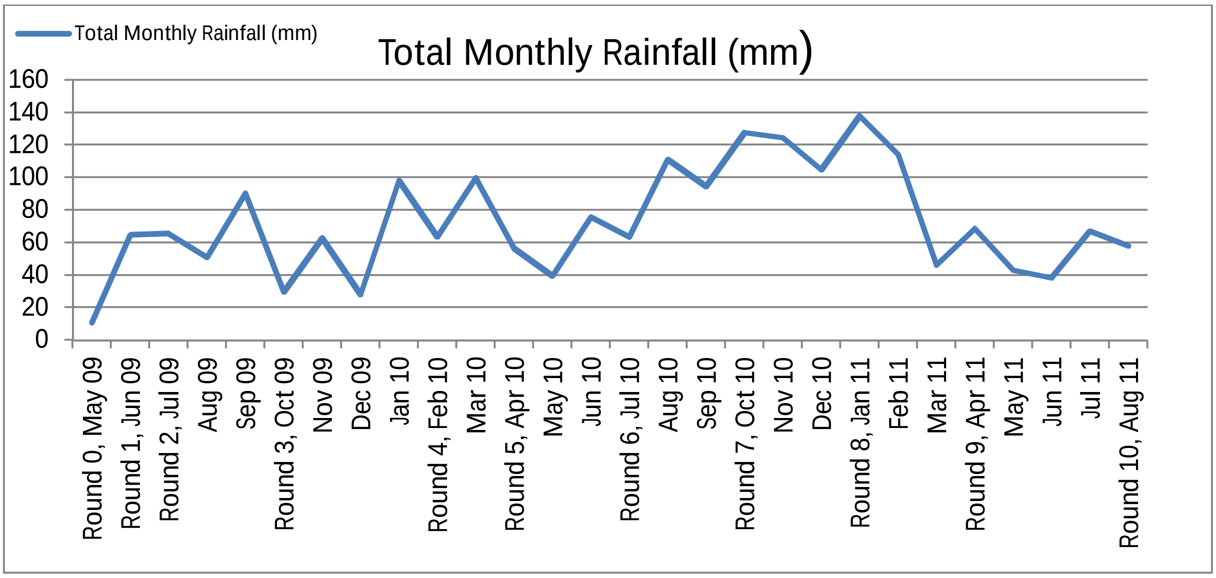

Figure 2 Rainfall data for the study area for the 27 month monitoring period from May 2009 to August 2011

3.2 Analysis of all Vegetation and Structural Factors across all sites

Results for all of the ecological factors assessed are shown in Table 4 and Table 5.

Ten vegetation factors displayed statistically significant differences based on the treatment/time interaction (Table 4): Litter (%), Introduced tussock cover (%), Bare Ground (%), Overall Introduced species cover (%), Total Species Richness, Native Species Richness, Introduced Species Richness, *Austrostipa* spp. (%), Native Grass cover >0.3 m, and Introduced grass cover >0.3 m. These ten factors have been analysed in further detail in Figure 3 - Figure 12 below.

Table 4 The results of the linear mixed modelling for the 18 vegetation and structural factors

Factor	Time		Treatment		Treatment x Time	
	χ^2	*P*	χ^2	*P*	χ^2	*P*
Native tussocks (%)	40.3	<0.001	45.2	<0.001	30.2	0.020
Native forbs (%)	35.3	<0.001	30.8	<0.001	19.3	0.256
Bryophytes / lichen (%)	84.7	<0.001	7.2	0.028	18.4	0.305
Litter (%)	461.6	<0.001	19.3	<0.001	138.4	<0.001
Introduced tussocks (%)	256.9	<0.001	13.1	0.002	95.6	<0.001
Introduced forbs (%)	96.1	<0.001	22.3	<0.001	19.4	0.253
Bare ground (%)	249.1	<0.001	2.1	0.341	78.5	<0.001
Introduced species cover (%)	117.6	<0.001	27.0	<0.001	84.1	<0.001
Total species richness	423.4	<0.001	96.8	<0.001	53.7	<0.001
Native species richness	352.7	<0.001	172.3	<0.001	55.2	<0.001
Introduced species richness	257.9	<0.001	33.2	<0.001	43.5	<0.001
Austrodanthonia[2] spp. (%)	5.5	0.783	18.3	<0.001	16.5	0.416
Austrostipa spp. (%)	29.3	<0.001	23.4	<0.001	76.1	<0.001
Inter-tussock distance (cm)	53.5	<0.001	9.5	0.009	23.8	0.100
Native grass cover <0. 3 m	35.7	<0.001	41.1	<0.001	33.4	0.008
Native grass cover >0.3 m	47.9	<0.001	4.7	0.093	59.7	<0.001
Introduced grass cover <0.3 m	279.6	<0.001	9.6	0.009	33.5	0.008
Introduced grass cover >0.3 m	309.4	<0.001	27.8	<0.001	52.2	<0.001

Note: We tested time (months since the pre-slabbing), treatment (control, laydown and slab) and the interaction. D.f. is the degrees of freedom, and for time = 9, treatment = 2 and the interaction = 16. , χ^2 is the Wald is the statistic equivalent to the F statistic and *P* is the significance level.

[2] [2] The genus *Austrodanthonia* has undergone taxonomic review and is now known as *Rytidosperma*

Table 5 shows the change in mean (and standard error) for all of the assessed vegetation and structural factors (pooling treatments), during each round of monitoring across the 27 month period. These data complement the time analysis in Table 4, and illustrates the general trends and direction of change in the measured vegetation and structural factors.

The following trends were observed across all vegetation and structural factors (combined across the treatment types) over the 27 month monitoring period:

- A general linear increase in Native Tussock cover (%), Introduced Tussock cover (%), Introduced Species cover (%), Native Species Richness, *Austrostipa* spp. (%), Native Grass cover <0.3 m, Native grass cover >0.3 m, Introduced Grass Cover <0.3 m, and Introduced Grass cover >0.3 m;
- A general linear decrease general decrease observed across all of the treatment types throughout the 27 month monitoring period for Introduced forbs (%);
- No strong trend was observed across all of the treatment types throughout the 27 month monitoring period for the following vegetation factors: Native Forbs (%), Bryophytes/Lichen (%), *Austrodanthonia*[3] spp. (%) and Inter-tussock distance (cm); and
- A polynomial pattern was observed across three treatments where there was a peak between monitoring rounds 4 – 6 (5 – 14 months post slabbing): Bare Ground (%), Total Species Richness, and Introduced Species Richness.

Table 5 The change in mean cover, richness (and standard error) for the 18 vegetation and structural factors across the time periods from the pre-survey to the 26 month survey period

Time	Pre-survey	1 month	2 months	5 months	11 months	14 months	17 months	20 months	23 months	26 months
Native tussocks (%)	2.9 (0.5)	1.9 (0.3)	4.6 (1.2)	1.0 (0.1)	11.3 (2.8)	11.3 (2.4)	7.0 (2.4)	10.7 (2.4)	11.0 (3.1)	10.1 (3.3)
Native forbs (%)	0.4 (0.1)	0.1 (0.0)	0.0 (0.0)	0.7 (0.2)	1.0 (0.2)	0.8 (0.2)	0.5 (0.1)	0.8 (0.1)	1.0 (0.3)	0.8 (0.1)
Bryophytes / lichen (%)	0.6 (0.1)	0.8 (0.1)	2.8 (0.6)	0.2 (0.0)	0.5 (0.1)	1.4 (0.4)	0.8 (0.1)	0.8 (0.2)	0.6 (0.1)	0.7 (0.1)
Litter (%)	29.4 (3.9)	2.3 (0.6)	2.6 (0.7)	1.2 (0.4)	1.3 (0.2)	0.9 (0.1)	1.5 (0.2)	1.5 (0.3)	2.4 (0.5)	3.2 (1.0)
Introduced tussocks (%)	35.8 (4.2)	59.5 (2.5)	56.3 (3.2)	49.8 (3.0)	40.2 (3.5)	63.4 (3.5)	72.9 (2.9)	75.1 (2.8)	78.3 (2.9)	81.8 (3.0)
Introduced forbs (%)	18.4 (2.1)	12.4 (1.7)	11.3 (1.4)	7.5 (1.1)	12.2 (1.9)	9.6 (1.3)	13.6 (2.2)	4.9 (1.0)	4.2 (1.1)	1.6 (0.4)
Bare ground (%)	7.3 (1.8)	22.8 (2.8)	31.3 (3.0)	30.8 (3.5)	22.9 (3.4)	11.9 (2.2)	3.2 (0.8)	4.4 (1.4)	2.4 (1.0)	1.9 (1.0)
Introduced species cover (%)	67.8 (2.4)	67.1 (3.6)	69.5 (2.0)	60.0 (3.2)	53.2 (4.3)	73.3 (3.0)	81.7 (2.2)	78.9 (2.8)	82.3 (2.4)	81.8 (3.0)
Total species richness	13.4 (0.4)	12.9 (0.6)	15.2 (0.4)	13.8 (0.6)	20.8 (0.6)	19.5 (0.4)	18.8 (0.6)	21.2 (0.5)	20.2 (0.6)	16.4 (0.8)
Native species richness	2.5 (0.2)	2.3 (0.2)	2.5 (0.2)	2.9 (0.2)	5.2 (0.3)	4.3 (0.3)	4.1 (0.3)	6.3 (0.3)	6.0 (0.4)	5.2 (0.4)
Introduced species richness	10.9 (0.3)	10.6 (0.4)	12.7 (0.3)	10.9 (0.5)	15.7 (0.6)	15.2 (0.4)	14.7 (0.4)	14.9 (0.4)	14.2 (0.5)	11.3 (0.5)
Austrodanthonia[4] spp. (%)	1.5 (0.5)	0.4 (0.1)	2.2 (0.7)	0.3 (0.1)	3.0 (1.8)	2.6 (1.5)	1.9 (1.5)	3.9 (1.3)	3.5 (1.7)	0.6 (0.3)
Austrostipa spp. (%)	0.8 (0.2)	0.9 (0.2)	1.4 (0.8)	0.2 (0.1)	1.1 (0.3)	0.7 (0.2)	1.6 (0.7)	2.4 (0.8)	0.6 (0.2)	5.4 (2.6)
Inter-tussock distance (cm)	18.1 (0.6)	20.7 (0.8)	18.8 (1.1)	25.1 (1.3)	20.4 (1.3)	18.8 (0.8)	22.1 (1.3)	24.4 (1.5)	23.5 (1.1)	19.1 (1.0)
Native grass cover <0.3 m	2.0 (0.4)	2 (0.4)	4.6 (1.2)	0.7 (0.1)	18.5 (4.8)	11.9 (2.8)	8.1 (3.0)	11.7 (2.9)	12.8 (3.9)	13.8 (5.5)
Native grass cover >0.3 m	0.2 (0.1)	0.4 (0.1)	0.3 (0.0)	0.1 (0.0)	0.8 (0.1)	0.6 (0.0)	0.7 (0.2)	0.9 (0.1)	0.8 (0.1)	1.3 (0.5)
Introduced grass cover <0.3 m	53.7 (2.9)	60.7 (2.6)	56.8 (3.2)	55.6 (4.7)	54.8 (6.1)	72.8 (4.6)	104.8 (5.4)	89.9 (4.0)	95.0 (4.3)	133.1 (6.0)
Introduced grass cover >0.3 m	0.1 (0.0)	0.3 (0.0)	0.2 (0.1)	0.8 (0.3)	0.7 (0.1)	0.7 (0.1)	5.5 (1.4)	1.4 (0.1)	3.3 (0.5)	14.5 (1.7)

[4] The genus *Austrodanthonia* has undergone taxonomic review and is now known as *Rytidosperma*

3.3 Analysis of Vegetation Factors against Treatment

Further to Table 5 above, we examined the mean (and standard error) for the 18 vegetation and structural factors measured over time, but with the three treatments separated. This data complements interpretation of the linear mixed models presented in Table 4, and provides a visual interpretation of the change that occurred in the experiment over time. We present the results only ten vegetation factors, which are those that displayed a significant effect of time and treatment (i.e., the interaction, see Table 4) and these are described below.

3.3.1 Litter Cover (%)

There was an immediate decrease in Litter cover (%) for all of the three treatments within the first month after the slabbing experiment began. Over the remaining 24-25 months Litter Cover (%) remained low for all of the treatments with little variation. For all of the treatments, Litter cover (%) did not reach the higher levels recorded in round one of the monitoring across the 27 month period (See Figure 3).

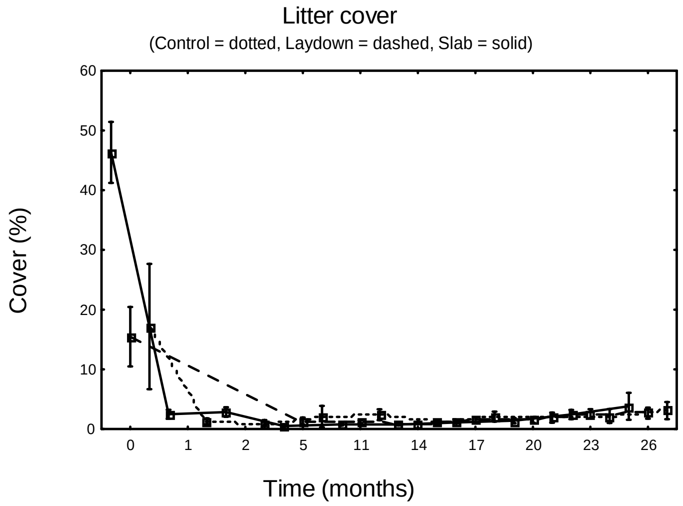

Figure 3 Mean and standard error of change in Litter Cover (%) over time categorised by treatment

3.3.2 Introduced Tussock Cover (%)

There was an overall increase in Introduced Tussock grass cover (%) across the three treatments over the 27 month monitoring period. The slab treatment showed the greatest increase in the cover (%) of Introduced Tussock grasses over time. All treatments experienced a slight decrease in Introduced Tussock grass cover (%) between months 5 and 11 after the slabbing began. The Slab treatment exhibited the highest average cover (%) of Introduced tussock cover when compared to the Control and Laydown treatments (See Figure 4).

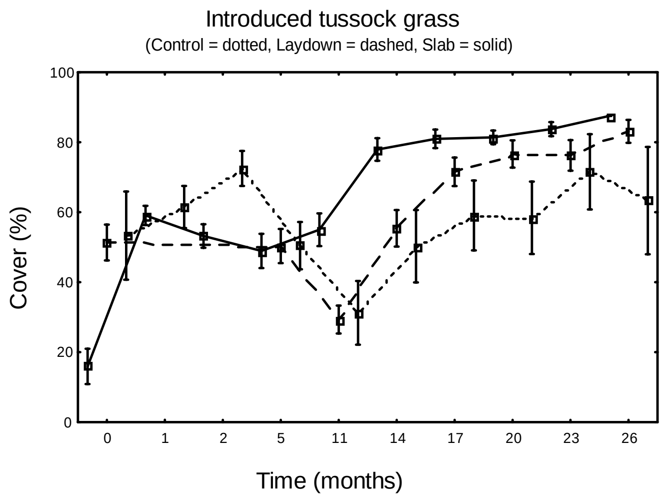

Figure 4 Mean and standard error of change in Introduced Tussock Cover (%) over time categorised by treatment

3.3.3 Bare Ground (%)

There was generally an initial increase in Bare Ground cover (%) for all three treatments. The three treatments then followed a similar trend and the Bare Ground cover (%) observed at the sites decreased significantly from between 5-17 months after the experiment began. However, overall there was a slight decrease in Bare Ground cover (%) for all of the treatments over the 27 month monitoring period (see Figure 5).

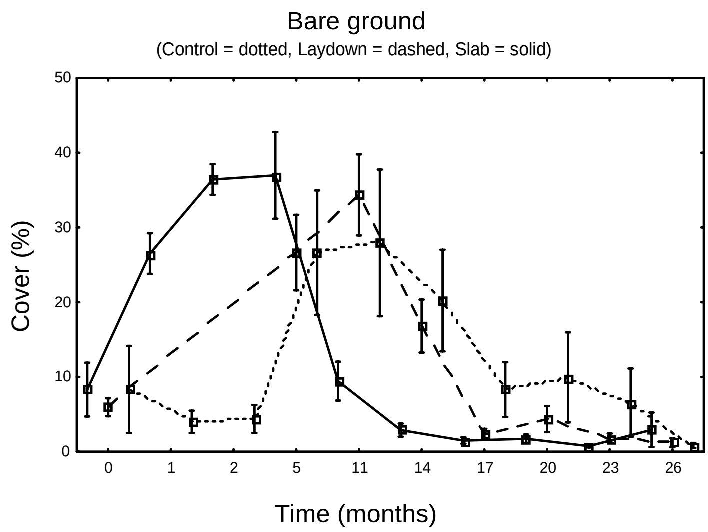

Figure 5 Mean and standard error of change in Bare Ground (%) over time categorised by treatment

3.3.4 Introduced Species Cover (%)

The three treatments followed a similar trend in relation to Introduced species cover (%) across the sites. The three treatments all exhibited a general decrease in the cover (%) of introduced plants until between 5-11 months when there was a general increase again in introduced species cover for the remainder of the 27 month monitoring period. The Slab treatment exhibited the highest average cover (%) of Introduced species when compared to the Control and Laydown treatments (see Figure 6).

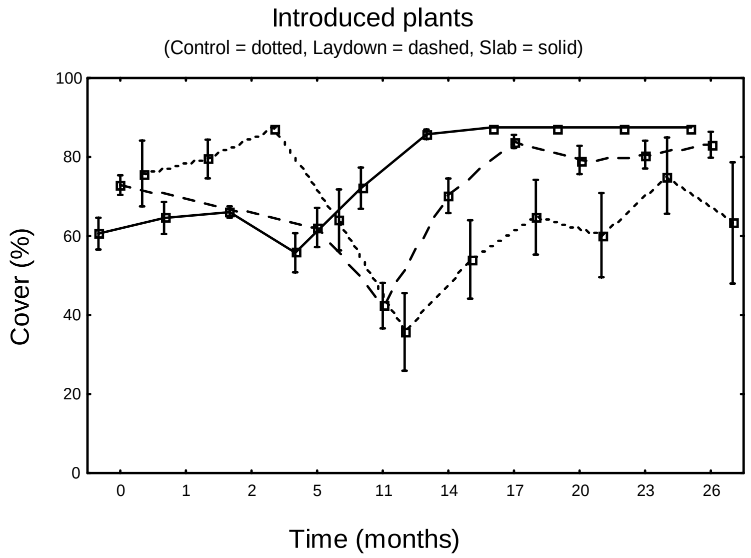

Figure 6 Mean and standard error of change in Introduced Species Cover (%) over time categorised by treatment

3.3.5 Total Species Richness

The three treatments followed a similar trend in relation to Total Specie Richness across the sites. The three treatments all exhibited a general increase in total species richness until 11 months after the experiment began when richness began to gradually decrease. Species richness remained the highest on average in the Laydown sites when compared to the Control and the Slab treatments (Figure 7).

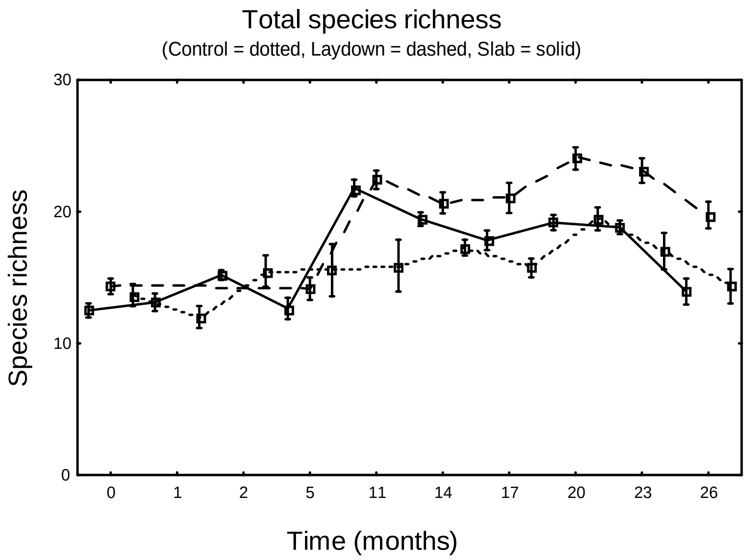

Figure 7 Mean and standard error of change in Introduced Total Species Richness over time categorised by treatment

3.3.6 Native Species Richness

The three treatments followed a similar trend in relation to Native Species Richness across the sites. After five months with relatively little variation, the three treatments all exhibited a general increase in native species richness for the remaining 22 months of the monitoring period. Both the Slab and Laydown treatments exhibited a minor decrease in native species richness between 23-27 months; however this may be due to the absence of ephemeral natives during autumn/winter. Native Species richness remained the highest on average in the Laydown sites when compared to the Control and the Slab treatments (Figure 8).

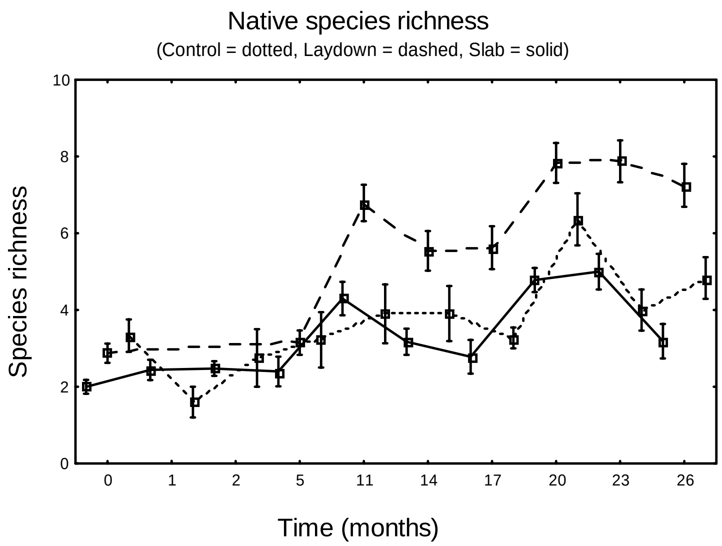

Figure 8 Mean and standard error of change in Native Species Richness over time categorised by treatment

3.3.7 Introduced Species Richness

The three treatments followed a similar trend in relation to Introduced Species Richness across the sites. After five months with relatively little variation, the laydown and slab treatments both exhibited a general increase in introduced species richness which then peaked between 11-20 months after the experiment began. After monitoring 20 months there was a general decrease in Introduced species richness across all of the treatments, with the Laydown areas exhibiting the highest average level of introduced species richness (see Figure 9).

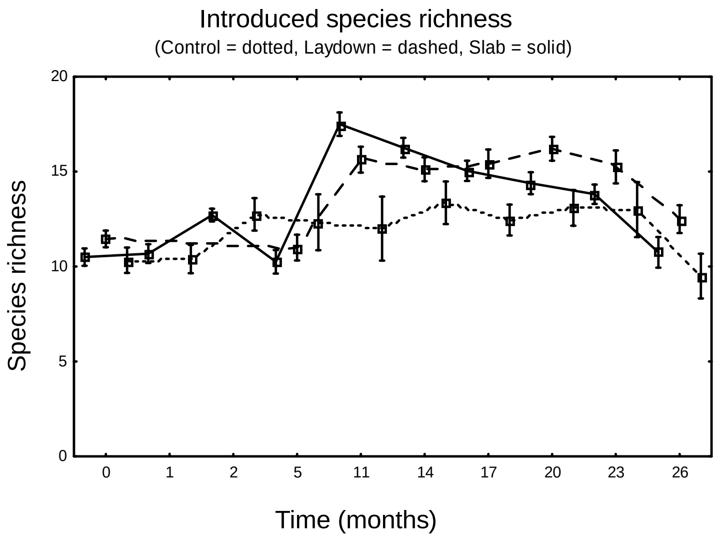

Figure 9 Mean and standard error of change in Introduced Species Richness over time categorised by treatment

3.3.8 *Austrostipa* spp. (%)

There was relatively little variation in *Austrostipa* spp. cover (%) across the three treatments until 23 months after the experiment began when there was a substantial increase in the cover of *Austrostipa* spp. in the control treatment. There was generally a higher cover of *Austrostipa* spp. in the Laydown and Control treatments when compared to the Slab treatment (See Figure 10).

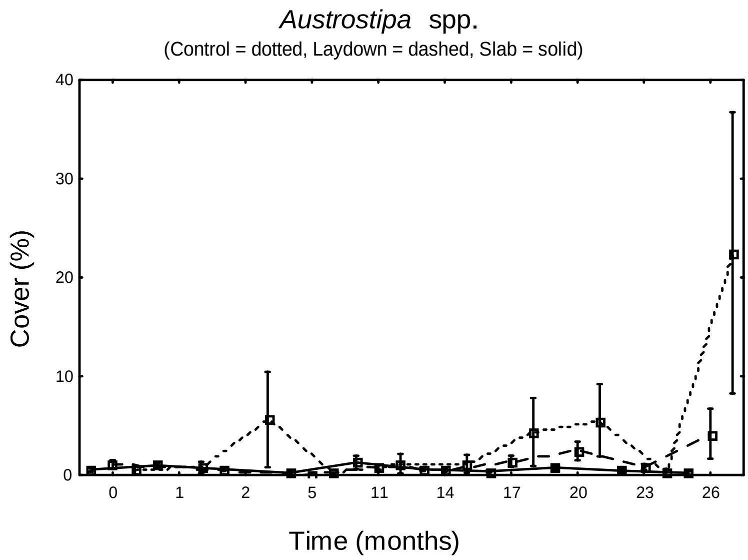

Figure 10 Mean and standard error of change in Austrostipa spp. (%) over time categorised by treatment

3.3.9 Native Grass Cover > 0.3 m

There was relatively little variation in Native Grass cover (>0.3 m) across the three treatments until 23 months after the experiment began when there was a substantial increase in Native Grass cover (>0.3 m) on average in the Control treatment (see Figure 11).

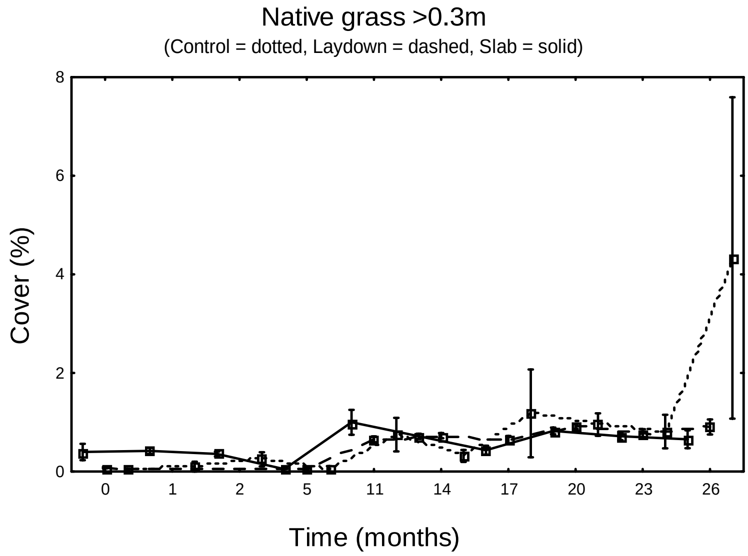

Figure 11 Mean and standard error of change in Native Grass over > 0.3 m over time categorised by treatment

3.3.10 Introduced Grass Cover > 0.3 m

There was relatively little variation in Introduced Grass cover (>0.3 m) across the three treatments until 14-17 months after the experiment began when there was an intermediate peak in the cover of Introduced grasses >0.3 m in both the Slab and Control treatments. This peak was followed by a decrease in introduced covers for these two treatments until 20 months after the experiment began. The cover of introduced grasses >0.3 m then increased markedly across all of the treatments between 20-27 months. The Slab treatment had, on average, the highest cover of introduced grasses >0.3 m (see Figure 12).

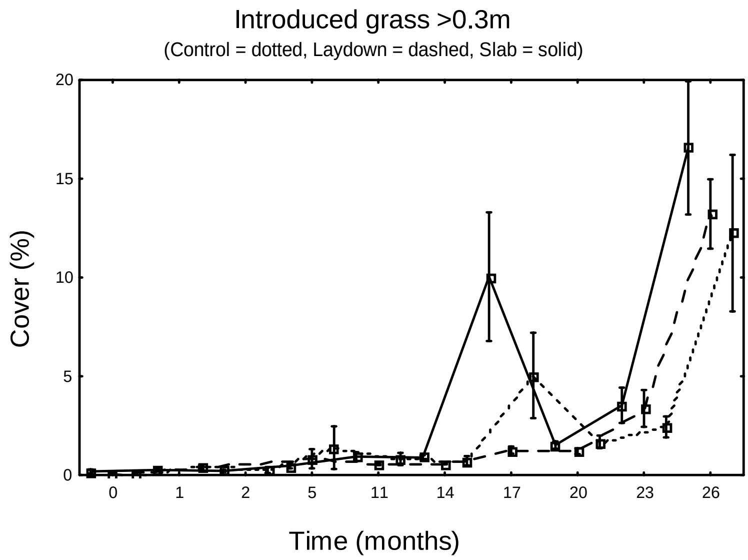

Figure 12 Mean and standard error of change in Introduced Grass Cover > 0.3 m over time categorised by treatment

4. Fauna Results

The aims of the GSM monitoring undertaken as part of the Habitat Slab Replacement experiment were to determine whether GSM larvae are able to survive the slabbing process, and whether 'slabbing' improves habitat reinstatement for the GSM compared to the project's standard reinstatement method. The aim of the experiment was not to determine whether there was a decline in the overall GSM population due to construction activities but merely to determine whether they were able to survive this particular reinstatement technique; however, depending on the results obtained, it may have been possible to infer information on a decline.

Surveys were undertaken of both the pupae and adult life stage of the GSM after the habitat slabs had been replaced.

During the searches for GSM pupa cases, all types of pupa cases and other discarded exoskeletons were collected. Across the six slab locations, and the two survey time-periods, over 1400 items were collected. Of these, approximately one third comprised a pupa case of some type. Forty-three of the pupa cases were confirmed as being from the GSM, which were collected from two locations only (property 328 and 335 north), and also only during the first search period (December 2009).

Adult GSMs were surveyed for each habitat slab treatment type a number of times over the flight season during the summer of 2009/2010 and the summer of 2010/2011. During the first summer of surveys GSM were recorded during each survey but were only recorded on one occasion during the second season of surveys. Adult GSMs were recorded from each different treatment type and from each set of slabs over the course of the adult survey period. A total of 883 adult GSM sightings were made during the course of the experiment within the treatments. Of the 481 individual treatment surveys; GSMs were recorded in large numbers on four or the 67 occasions GSMs were detected. The treatment types where GSM sightings were highest on any one occasion were:

Property 335 North; Timber Laydown 450 (297 sightings);

Property 327; Control – disturbed (153 sightings);

Property 335 North; Control – disturbed (99 sightings); and

Property 335 North; Timber Slab 450 (82 sightings).

5. Discussion

5.1 Flora Discussion

Though there was a distinct trajectory over time of increasing vegetation cover in all treatments, there was a significant variation across the slab and laydown treatments compared to the control sites. One of the key findings was the large degree of variability (both within the treatment plots and across the time periods) in most of the measured vegetation and structural variables over time, which will be in part a function of the natural seasonal variation in the cover, richness and abundance of annual and perennial grassland flora species. However, these seasonal cycles, changes in species composition, and increases in vegetation cover and structure of the grasslands were also compounded by the drought breaking rain, which fell in the first six months of the experiment. These are typical broad-scale climatic influences on natural long term field experiments, and provide interesting data on landscape responses to changing environmental conditions; however they do not detract from the core results which are the significant difference in the treatment effects on each ecological variable.

Overall, the results of the experiment strongly suggest that the HSR treatment is unlikely to be the most appropriate rehabilitation technique to: a) restore semi-native grassland habitat following ground disturbance, and b) promote GSM habitat, in relation to control treatments, for the first 27 months following disturbance. Assessment of ecological variables such as Native tussock cover, Native forb cover, Introduced tussock grass cover, Introduced species cover, Native species richness, *Austrodanthonia* cover, *Austrostipa* cover, Native grass cover (< and >0.3 m) and Introduced grass cover (< and >0.3 m) all indicate that the slab treatment routinely provides poor ecological outcomes in relation to either the laydown treatment or the controls, in that the introduced species and cover swamp the native species. This may have in part been facilitated by the sharp increase in rainfall to above average conditions just after the experiments inception.

These findings, though seemingly negative, have important implications for future grassland restoration efforts following disturbance associated with major infrastructure projects.

5.1.1 Variable floristic factors

The different floristic factors monitored across the 27 month period often exhibited predictable patterns. For instance, the percentage cover of bare ground exhibited an initially high reading for the slab treatment which then quickly stabilised one year later, while the control and laydown treatments followed a similar pattern merely delayed by three months. The cover of introduced species was unsurprisingly highest within the slab treatment, with a decrease in cover of introduced species between 5-11 months at a time when rainfall levels in the area were, on average, at their lowest for the 27 month monitoring period. The decrease in rainfall over this period was also correlated with the increase in bare ground observed, as well as an increase in the cover of native tussocks (%) across the three treatments. As rainfall levels increased a year in to the experiment, the cover of introduced species significantly increased with the highest levels of introduced species observed being present within the Slab treatment sites.

5.1.2 Intermediate Disturbance Hypothesis

The results of the Habitat Slab Replacement (HSR) experiment suggest that of the three treatment types (Slab, Laydown and Control), the most positive ecological restoration outcomes (e.g. greater native cover, richness, and lower introduced cover, richness) were usually achieved in the Controls. That is where the habitat is not disturbed by machinery interference, the native species remain more abundant and in higher cover. However, native species richness and total species richness was higher within laydown areas when compared to the Slab and Control areas. These results suggest that some degree of disturbance is required to maintain maximum possible native species richness to persist. In this case, the laydown treatment is intermediate when compared with the slab treatment and the controls in terms of its level of disturbance to the actual substrate. This aligns with the 'intermediate disturbance hypothesis', which suggests that species diversity is highest under moderate levels of disturbance (Hobbs and Huenneke 1992).

5.1.3 To Graze or Not to Graze?

The effects of stock grazing on native grassy ecosystems in temperate southern Australia are well documented; however, less is known about the potential of ecosystems to recover after a long history of stock grazing (Price *et al.* 2010). The properties assessed as a part of this project have been subject to historic grazing, probably for over 100 years. The cessation of grazing within the experimental plots for the 27 month monitoring period allowed for an interesting secondary tier of investigations as changes in structure and composition of the study sites were observed in relation to the surrounding landscape.

In Australia, the removal of stock often follows reservation for conservation (Lunt & Morgan 1999). The general aim of grazing exclusion in reserves is to improve native species richness and cover whilst simultaneously reducing the cover and richness of exotic species (Price et al. 2010). However, the limited data available for grazing exclusion within Australian communities suggest that grazing exclusion alone may not be enough to achieve this goal (Spooner and Briggs 2008, and Price *et al.* 2010).

For any rehabilitation or restoration works within a landscape that has been historically grazed, particularly when native biodiversity is one of the drivers and key indicators for success, then some level of grazing should be introduced as a form of land management. If some level of grazing is not undertaken then it is likely that introduced species cover will increase, and the richness of native species will decrease over time as they become outcompeted by vigorous weedy grasses that were previously kept in check by some form of livestock grazing. However, disturbance is also known to increase the invasion-proneness of communities and therefore poses an important problem for conservation management (Hobbs and Huenneke 1992). Recent studies suggest that for both plants and reptiles, there could be benefits from adopting a 'low-input' grazing system (Dorrough *et al.* 2012). The implications for the HSR experiment are obvious. The exclusion of grazing from the experiment, while undertaken in an attempt to allow the ROW to regenerate as rapidly as possible, has led to significant grassy weed growth within the treatment areas, when compared with the controls. In hindsight, the most appropriate management option may have been to exclude grazing for the initial 12 months post-construction, and then allow grazing back onto the experimental plots, to replicate land use of the surrounding property, and to keep rank weed growth in check.

Furthermore, as discussed above, grazing is likely to act as a form of intermediate disturbance, which helps to maintain the grasslands in some form of ecological equilibrium (semi-stable state), where disturbance-tolerant native graminoids and forbs are able to persist, and rampant weed growth is able to be managed. As a consequence, ecologically appropriate grazing regimes are deemed essential to help maintain native grassland composition, diversity and structure, and as a by-product, GSM habitat.

5.2 Fauna Discussion

There are multiple lines of evidence that suggest that far fewer GSM emerged during the 2010/2011 flight season than during the 2009/2010 season. The surveys undertaken as part of this project support this conclusion, as the numbers of GSM seen were well below the previous season within areas that had not been disturbed during construction as well as within disturbed areas. As the numbers of moths were depleted all across the state in a variety of disturbed and relatively undisturbed grassland habitat locations, it is not possible to conclusively comment on the relationship between the rehabilitation of the habitat slabs and the presence of GSM.

Given the differences between the 2009/2010 and 2010/2011 flight seasons, it is difficult to attempt to draw conclusions about the recovery of GSM populations (or the lack thereof) since the completion of construction (including within the habitat slab treatment areas). During the first post-construction flight season, 879 GSM were recorded within the habitat slab treatments. In contrast during the second post-construction flight season, only eight GSM were observed within the habitat slab treatments. The contrasting results in GSM recorded between the two flight seasons when considered against the weather conditions experienced, suggests that the emergence of GSM adults is reduced in years of above-average rainfall. However, the available pre-construction GSM data are too limited to draw any confident conclusions about the survivorship of the local GSM populations which may have been affected by the construction process, or the extent to which they are recovering.

6. Conclusions

Based on the results of the Habitat Slab Replacement (HSR) experiment we believe that the HSR method is not a viable mitigation measure to reduce impacts of disturbance associated with linear infrastructure projects upon native grasslands and associated fauna species such as GSM. Conversely, it is likely that standard habitat reinstatement measures (e.g. retention and respreading of topsoil) are just as likely to return the grassland to a state as close as possible to its pre-disturbance state.

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Appendix A

Data Sheet for Habitat Slab Experiment

Flora Monitoring

31 21633 13: Golden Sun Moth Habitat Slab Replacement Floristic Survey

Property #		Date		Observers	
Easting		Photo no.'s		Quadrat dimensions	
Northing		Control site	Y / N	Overall cover abundance of vegetation	
Time started		Time completed		Site no. / ID	

1. Species abundance, Vertical structure and Overall composition

+	1	2	3	4	5	6
<1%	<5%	5<15%	15<25%	25-50%	50-75%	75-100%

Native species (tick if present)	**√ ?**	**Cover**
Austrodanthonia caespitosa		
Austrodanthonia duttoniana		
Austrodanthonia setacea		
Austrodanthonia sp.		
Austrostipa rudis subsp. *rudis*		
Austrostipa sp.		
Cassinia sp.		
Dichondra repens		
Elymus scaber var. *scaber*		
Epilobium hirsutum		
Eucalyptus camaldulensis		
Euchiton sp.		
Juncus amabilis		
Juncus bufonius		
Juncus pallidus		
Juncus flavidus		
Juncus sp.		
Hypericum gramineum		
Lomandra filiformis		
Lythrum hyssopifolia		
Microlaena stipoides var. *stipoides*		
Oxalis perennans		
Pseudognaphalium luteoalbum		
Rumex brownii		
Senecio quadrifida		
Themeda triandra		
Unknown Native Poaceae		

Introduced species (tick if present)	**√ ?**	**Cover**
Acetosella vulgaris		
Agrostis sp.		
Anthoxanthum odoratum		
Arctotheca calendula		
Bromus diandrus		
Bromus hordeaceus subsp. *hordeaceus*		
Cirsium vulgare		
Conyza bonariensis		
Conyza sp.		
Cynodon dactylon var. *dactylon*		
Dactylis glomerata		
Festuca arundinacea		
Holcus lanatus		
Hordeum sp.		
Hypochoeris radicata		
Lactuca serriola		
Lepidium africanum		
Lolium sp.		
Lotus sp.		
Paspalum dilatatum		
Paspalum sp.		
Phalaris aquatica		
Phalaris minor		
Plantago lanceolata		
Plantago sp.		
Poa sp.		
Polygonum aviculare		
Romulea rosea		
Rubus fruticosus spp. *agg*		
Rumex sp.		
Setaria parviflora		
Sonchus sp.		
Trifolium sp.		
Vulpia sp.		
Unknown Introduced Poaceae		

Native graminoids % cover (inc.Juncus, Lomandra, Dianella etc)		Introduced graminoids % cover (inc.Cynodon)	
Native forbs % cover		Introduced forbs % cover	
Bryophytes/Lichens % cover		Bare ground % cover	
Litter % cover		Overall % cover of introduced species	

2. Vertical Structure

	0-10cm	10-30cm	30-100cm	>100cm
Native grasses (Poaceae)				
Introduced grasses				
Native sedge or rush (eg. *Lomandra, Juncus*)				
Introduced sedge or rush				
Native forbs				
Introduced forbs (inc. *R.rosa*)				

3. Inter tussock distance (irrespective of whether tussock native or introduced, alive or dead) for 10 random points within treatment/control area. Note: SM = Soil Moisture

* Distance (cm) to edge of closest tussock (inc. Juncus) **with diameter of 3 cm** (if Cynodon, distance to closest point where plant is completely attached to the ground, not just a rooting point along a rhizome).

1	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

2	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

3	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

4	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

5	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

6	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

7	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

8	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

9	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

10	Species	Distance*	SM %	SM mv
1				
2				
3				
4				

Appendix B

Habitat Slab Replacement location and treatment IDs

Flora Monitoring

Legend	
C	Control
DS	Treatment 1 - Disturbed, seeded
ST200	Treatment 2 - Slab, Timber, 200 mm deep
ST450	Treatment 3 - Slab, Timber, 450 mm deep
SG200	Treatment 4 - Slab, Geofabric, 200 mm deep
SG450	Treatment 5 - Slab, Geofabric, 450 mm deep
LT200	Treatment 6 - Laydown, Timber, 200 mm deep
LT450	Treatment 7 - Laydown, Timber, 450 mm deep
LG200	Treatment 8 - Laydown, Geofabric, 200 mm deep
LG450	Treatment 9 - Laydown, Geofabric, 450 mm deep

Property	Treatment	Treatment code	Easting	Northing	Flora ID
326 North	Disturbed sift and seeded	DS	362109	5877739	1.5L
326 North	Timber 450 laydown	LT450	362082	5877744	1.5L
326 North	Timber 450 slab	ST450	362098	5877749	1.4S
326 North	Geofab 200 laydown	LG200	362075	5877754	1.4L
326 North	Timber 200 laydown	LT200	362066	5877766	1.3L
326 North	Geo 200 slab	SG200	362090	5877766	1.2L
326 North	Timber 200 slab	ST200	362079	5877774	1.2S
326 North	Control undisturbed	C	362058	5877775	1.2L
326 North	Geo 450 laydown	LG450	362049	5877787	1.1L
326 North	Geo 450 slab	SG450	362062	5877796	1.1S
326 Sth	disturbed control	DS	362213	5877593	2.5S
326 Sth	Timber 200 laydown	LT200	362190	5877596	2.5L
326 Sth	Timber 200 slab	ST200	362203	5877604	2.5S
326 Sth	Control	C	362182	5877605	2.4L
326 Sth	Timber 450 lay	LT450	362174	5877615	2.3L
326 Sth	timber 450 slab	ST450	362187	5877625	2.3S
326 Sth	G450 lay	LG450	362165	5877628	2.2L
326 Sth	G450 slab	SG450	362178	5877636	2.2S
326 Sth	G200 lay	LG200	362158	5877638	2.1L
326 Sth	G200 slab	SG200	362168	5877648	2.1S
327	G450 lay	LG450	362509	5877276	3.5L
327	G200 lay	LG200	362499	5877284	3.4L
327	G450 slab	SG450	362520	5877288	3.5S
327	Control	C	362488	5877293	3.3L
327	G200 slab	SG200	362509	5877297	3.4S
327	timber 450 lay	LT450	362477	5877300	3.2L
327	timber 200 lay	LT200	362465	5877309	3.1L
327	timber 450 slab	ST450	362488	5877313	3.3S
327	timber 200 slab	ST200	362477	5877321	3.2S
327	Distrubed control	DS	362466	5877329	3.1S
328	Control	C	362868	5876877	4.5L
328	Disturbed control	DS	362880	5876888	4.5S
328	T450 lay	LT450	362860	5876895	4.4L
328	T 450 slab	ST450	362873	5876900	4.4S
328	G200 lay	LG200	362853	5876907	4.3L
328	G200 slab	SG200	362868	5876913	4.3S
328	G450 lay	LG450	362847	5876921	4.2L
328	G450 slab	SG450	362860	5876925	4.2S
328	T200 lay	LT200	362841	5876935	4.1L
328	T200 slab	ST200	362854	5876941	4.1S
335 North	Timber 200 slab	ST200	363138	5875101	5.5S
335 North	Timber 200 laydown	LT200	363123	5875102	5.5L

Property	Treatment	Treatment code	Easting	Northing	Flora ID
335 North	Geo 200 slab	SG200	363137	5875115	5.4S
335 North	Geo 200 lay	LG200	363119	5875116	5.4L
335 North	G450 lay	LG450	363117	5875131	5.3L
335 North	G450 slab	SG450	363137	5875131	5.3S
335 North	Disturbed Control	DS	363138	5875146	5.2S
335 North	Control	C	363122	5875166	5.2L
335 North	Timber 450 lay	LT450	363120	5875179	5.1L
335 North	Timber 450 slab	ST450	363133	5875193	5.1S
335 South	Control	C	363145	5874908	6.5L
335 South	G200 lay	LG200	363145	5874919	6.4L
335 South	G200 slab	SG200	363160	5874921	6.5S
335 South	T450 lay	LT450	363141	5874933	6.3L
335 South	T450 slab	ST450	363158	5874935	6.4S
335 South	T200 lay	LT200	363140	5874948	6.2L
335 South	T200 slab	ST200	363155	5874950	6.3S
335 South	G450 lay	LG450	363136	5874962	6.1L
335 South	G450 slab	SG450	363152	5874965	6.2S
335 South	Disturbed control	DS	363150	5874979	6.1S

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